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Bending assignation for reinforced concrete beams in the long-time process considering the impact of creep contraction and impact of reinforcement percentage

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Abstract

Main factors that impact creep and shrinkage of concrete as well as the impact of so called "creep and shrinkage in static systems", basic hypothesis of linear theories of the creep of concrete. There are described main hypothesis on the concrete characteristics, it is given also the description on the status of deformation-strain, relation of the creep and relaxing according to EC-2, phenomena which are presented in figures as well as it is given the basic rheology relation according to the McHenry principle as well as the tangential module of concrete elasticity in the case of oldness "t_0", $Ec(t_0)$ according to EC-2, CEB-FIB'78, ACI and according to the regulation of former Yugoslavia where it is described in details: theory of oldness, theory of inheriting of elasticity and theory of inheritance-oldness.

Determination of inclination for reinforced concrete during time having in mind the creep and shrinkage, creep and impact of concreting percentage. The calculations are made with these methods:

- Numerical integration method
- Bilinear method first case
- Bilinear method second case
- According to Eurocode-2

Introduction

Subject of rheology is to describe the mechanical properties rheology of various materials under different deformation modes, where simultaneously, it can be shown the ability of the flow and accumulation of reversible deformations.

Rheology duty is to determine the principles and basic summary, which can be obtained correlations between various physical and geometrical sizes.

For the first time, the problem of rheology noted by German physician W. Weber, in 1835 during work on glass silk fibbers, which have been loaded under straining. Later, R. Kolrausch and F. Kolarausch in 1863 and 1866, and then J. Hop Kinson in 1878, for the first time, described the legality of these phenomena.

Is the number of researchers in this field in recent years.

All these works are classified into three groups of theories:

1. On the first entering the work group which get study physico-chemical phenomenon of concrete phenomena,
2. In second group includes those experimental work in laboratories, workshops and facilities available, executed in different environmental conditions, load dimensions, etc..
3. In the third group of work, enter them theoretical works in which, based on the total performance records of the proceedings of the first group and the second.

Basıc characterıstıcs of rheology

Basic rheological properties: elasticity, viscosity-elasticity and plasticity, and Composite rheological properties are: basic properties rheology combinations. Also, these can be classified depending on the variability of the properties, in consequence of the time:

- Feature steady flow past,
- Feature anti steady flow past.

Bending assignation for Statically determinate systems

1. According to the rules RBBA'87
2. According to the rules Eurocode-2

Deformations limits

In calculating the construction of reinforced concrete, according to the deformation limit definitely, must be shown that the deformation limit of all construction elements - in general, the action of unfavorable non loads during use, satisfies functionality of criteria. For the construction of reinforced concrete elements, which directly or indirectly, supported the formation of the body of the object, respectively, various machinery, equipment and devices, it is possible to show that the expected deformation of these elements t 'respond to the limits allowed, so as not to obstruct or endanger its normal functioning.

Limitation of deformation is necessary to remove, avoiding the aesthetic and psychological effects.

However, the exact knowledge of the state of deformation of the elements of RC, often, it is necessary to appoint precise deflections.

This is expressed, mostly, cantilever holders large spaces, applied, mostly, to the bridges.

Determination of deflection

Border state of deformation of the elements of RC, under the influence of bending up, practically behavior of limited reductions .Deflection in condition v (t) of the elements from RC subject to a warp made during a certain time (t), often in practice calculations based on the principle of virtual work forces.

Deflections calculations are done with these methods according the rules RBBA-87:

1. Numerical Integration Method;
2. Bilinear method of order I-st
3. Order bilinear method II-d

2. Calculation of Deflection according Eurocode-2

Deformation of the elements and construction of reinforced concrete is allowed, provided that they do not come to harm basic elements and no constructive elements, in order not to come to the risk of the use of construction.

Deformation or bending is a general term that expresses the deformation, deflection, bending, extending or shortening, rotation and change of slope.

Here we will consider bending which represents the reduction of construction elements.

Reductions prediction is a very complex task, since here it comes to the large number of factors that change the position of the neutral axis and change over time.

To obtain a small reduction of construction elements during long-term and lasting impacts, should attend the instructions below:

- Slenderness of the element to be as minimized l_{eff} / d;
- When it is possible to leave the simple beams;
- Acquired high brand concrete; much smaller factor w/c, maintained concrete during hardening;
- To reduce to a minimum the cracks, or when it is possible to use prestressed concrete.
- EC-2, provided two options:

- The condition of the item without cracking, concrete armor and collaborate together in payload elements (load)-elastic condition;
- The condition of the item completely cracked concrete participation in straining overlooked. For the calculation of the deflections we get the expressions:
- where $f_{tot} \leq f_k$,

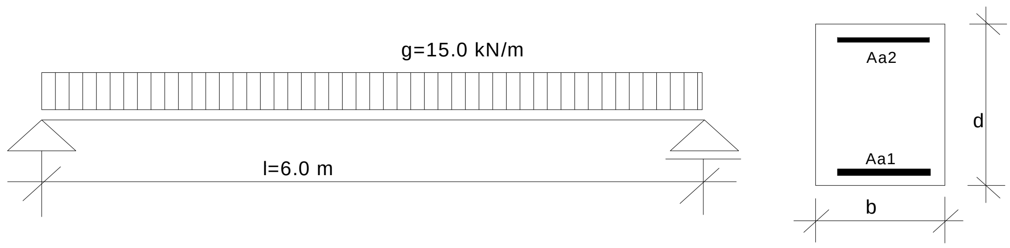
Numerical example

Controlled deflection of so-called short time and long time between reinforced concrete element middle which is subject to bending of clean, under continual load action, the creep and shrinkage of the concrete. Control of deflection made for four cases Reinforcing cross section.

I^{st} Case : $Aa_1=3\phi19=3x2{,}84=8{,}52cm^2$,$Aa_2=2\phi19=2x2{,}84=5{,}68cm^2$
$\Sigma(Aa_1+Aa_2)=14{,}2cm^2$
II^{nd} case: $Aa_1=4\phi19=4x2.84=11{,}36cm^2$, $Aa_2=2\phi19=2x2{,}84=5{,}68cm^2$
$\Sigma(Aa_1+Aa_2)=11.36+5.68=17{,}04cm^2$
III^{rd} case: $Aa_1=6\phi19=4x2.84=17{,}04cm^2$,$Aa_2=2\phi19=2x2{,}84=5{,}68cm^2$
$\Sigma(Aa_1+Aa_2)=22{,}72cm^2$
IV^{th} case: (symmetric cross section reinforcement)
$Aa_1=4\phi19=4x2.84=11{,}36cm^2$, $Aa_2=4\phi19=4x2{,}84=11{,}36cm^2$
$\Sigma(Aa_1+Aa_2)=22{,}72cm^2$

Control of deflection according rules RBBA 87
- Bilinear method;
- The method of numerical integration, and
- Check deflections according rules Eurocod-2

Data: g = 15.0 kN / m, l = 6.0 m, b / d = 30/50 [cm], RA 400/500, $\varphi_\infty = 2.5$, $\nu_u = l/300$.
* Determined module of elasticity in concrete in time t_0 load, after 28, 90, 180, 365 days and $t=\infty$. Relative humidity of the environment, after the concrete storage element to during the time t_s = 14 days, relative humidity RH = 100%. Where RH = 40%. Concrete is made with normal Portland cement.



Controlled deflection of so-called short time and long time between reinforced concrete element which is subject to pure bending , under continual load action, creep and shrinkage of the concrete. Control of deflections has made for four cases cross section of the element.

I^{st} case: Aa1=3ϕ19=3.2,84=8,52cm2, Aa2=2ϕ19=2.2,84=5,68cm2
Σ(Aa1+Aa2)=14,2cm2

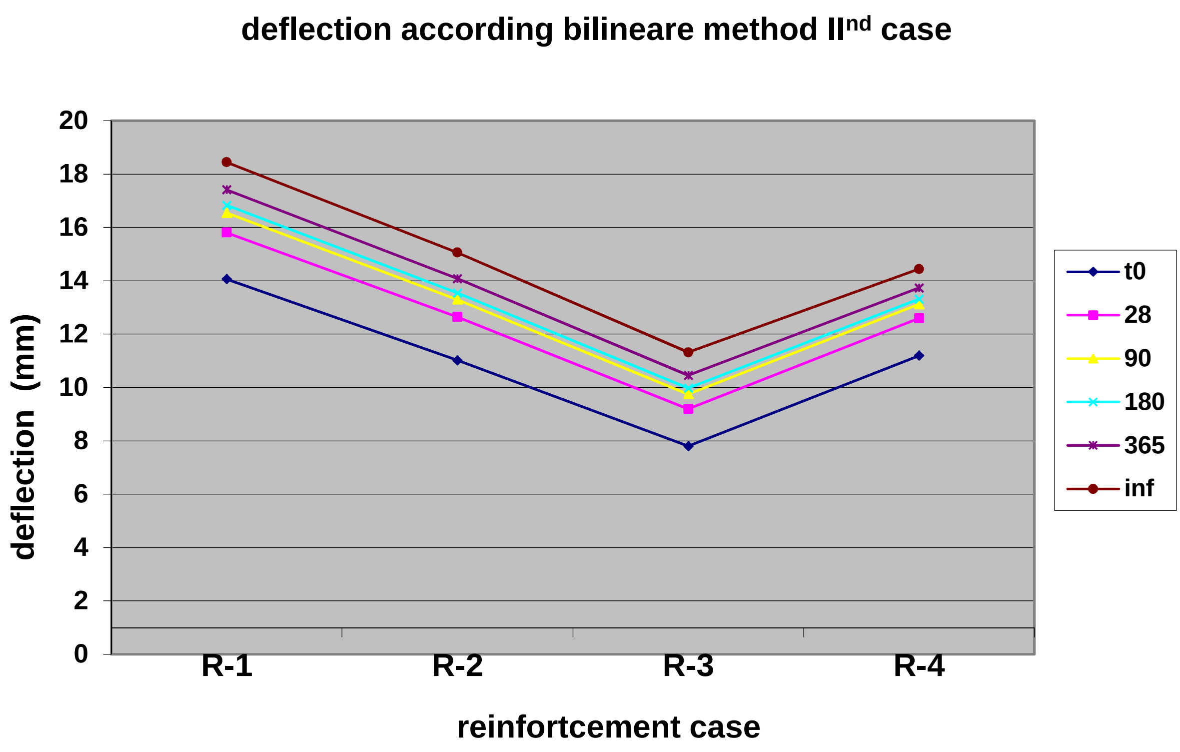
IInd case: Aa1=4ϕ19=4.2.84=11,36cm2, Aa2=2ϕ19=2.2,84=5,68cm2
Σ(Aa1+Aa2)=11.36+5.68=17,04cm2

IIIrd case: Aa1=6ϕ19=4.2.84=17,04cm2, Aa2=2ϕ19=2.2,84=5,68cm2
Σ(Aa1+Aa2)=22,72cm2

IVth case: (symmetric cross section reinforcement)
Aa1=4ϕ19=4.2.84=11,36cm2, Aa2=4ϕ19=4.2,84=11,36cm2
Σ(Aa1+Aa2)=22,72cm2

Reinforced cases	Time (days)	Numerical Integration Method	Bilinear method of order I-st	Bilinear method of order II-nd	Allowed deflection (mm) l/300	Calculation made acc. EC-2	Allowed deflection (mm) l/250
Ist case A_{a1}=8.52 cm^4 A_{a2}=5.68 cm^4	t_0	9.662277	2.4456282	14.0616075	20.0	6.659801	24.0
	28	11.03519	4.0324468	15.8005083		7.200258	
	90	11.37188	4.7195133	16.5642825		8.900195	
	180	11.57973	4.9932536	16.8371447		9.814247	
	365	13.98437	5.5823726	17.410770		10.66392	
	∞	15.26105	6.6907006	18.4486387		12.54533	
IInd case A_{a1}=11.36 cm^4 A_{a2}=5.68 cm^4	t_0	7.663371	2.4294019	11.0217612	20.0	4.046563	24.0
	28	9.019351	3.9930903	12.6473038		4.349233	
	90	9.562943	4.6652651	13.2950638		5.318067	
	180	11.25444	4.9333339	13.5477084		5.821457	
	365	11.75113	5.5096175	14.081881		6.330044	
	∞	12.6602	6.5918366	15.0588499		7.41509	
IIIrd case A_{a1}=17.04 cm^4 A_{a2}=5.68 cm^4	t_0	5.5669338	2.3805237	7.80599566	20.0	2.118723	24.0
	28	6.760221	3.8732345	9.19099900		2.255508	
	90	7.246914	4.5083629	9.75525426		2.697026	
	180	8.469683	4.7607919	9.97720034		2.936431	
	365	8.916981	5.3020295	10.4498922		3.160965	
	∞	9.744662	6.3142558	11.3263351		3.662499	
IVth case A_{a1}=11.36 cm^4 A_{a2}=11.36 cm^4	t_0	7.640255	2.3441863	11.1934132	20.0	3.418423	24.0
	28	8.719158	3.7643659	12.5982685		3.644755	
	90	9.114362	4.3540035	13.1212623		4.340597	
	180	10.87737	4.58571	13.3197386		4.644977	
	365	11.23933	5.0772341	13.7294386		5.023153	
	∞	11.87139	5.9762861	14.444893		5.711564	

Figure.2



deflection according bilineare method IInd case
deflection (mm)
20
18
16
14
12
10
8
6
4
2
0
R-1
R-2
R-3
R-4
reinfortcement case
t0
28
90
180
365
inf

Figure.2

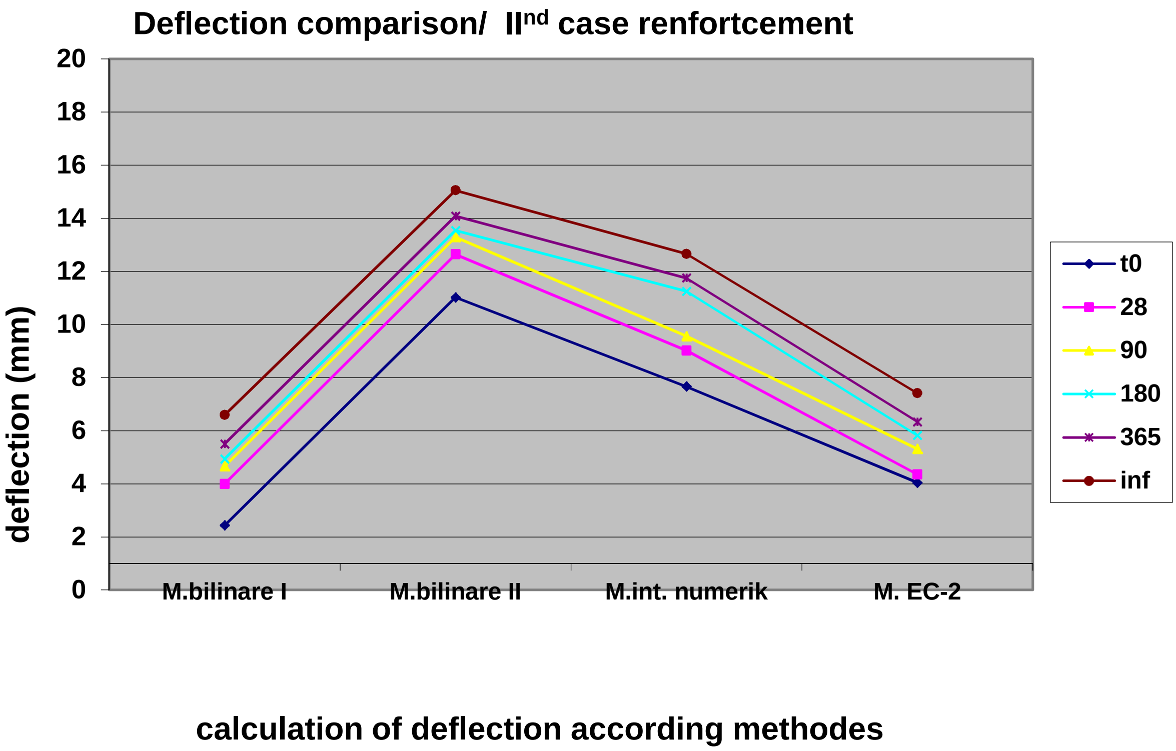


Figure. 3

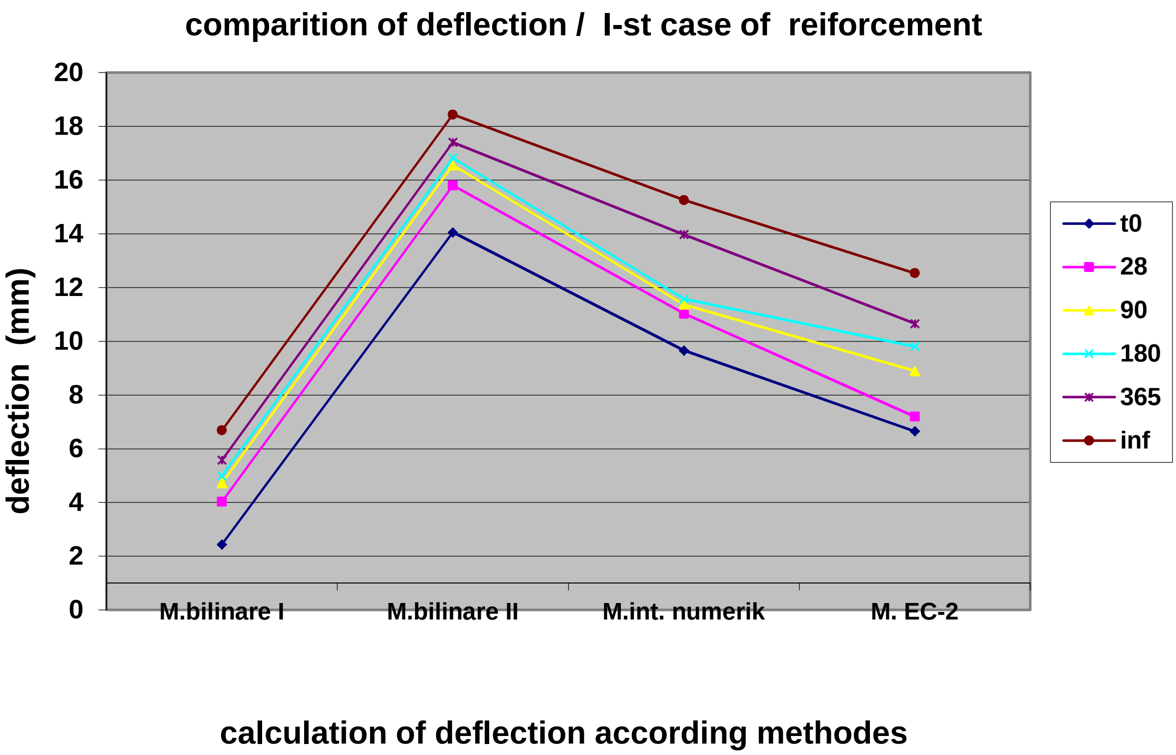


Figure.4

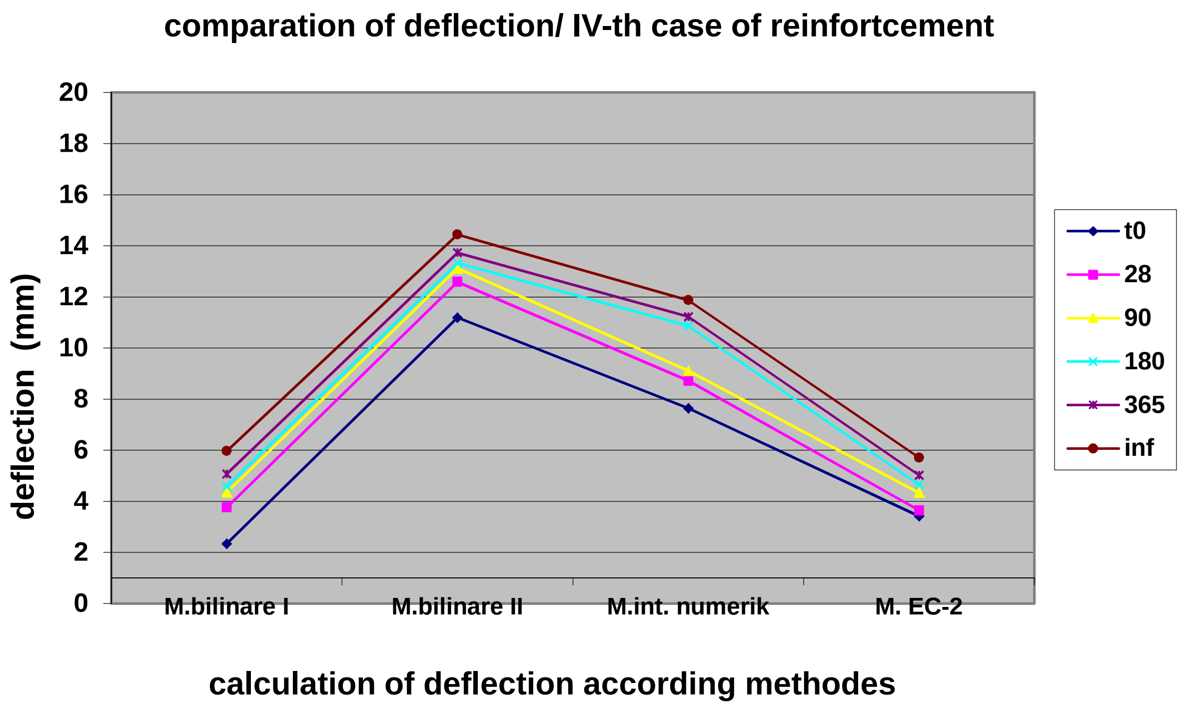


Figure.5

Conclusion

Check deflection is made among the space of reinforced concrete, the calculation is done by three methods for different times (t_0, 28, 90, 180, 365 and $t_:$) days. Cross section element of reinforced concrete, reinforced ribbed armature, where the amount of Reinforcing for four different cases.

Comparing the results show that deflection over time come increasing and that the first case, reinforcing this growth by comparing t_0 cross sections highs for the time $t=\infty$.

- Numerical integration method 1.579 times
- Method bilinear case I 2.730 times
- Bilinear case method II 1.311 times
- According to the Eurocode-2 1.883 times

For the second case, where the cross-sectional been added reinforcement by 20%, compared to the first case reinforcing this growth, compared t_0 reductions with reductions for time $t=\infty$.

- Numerical integration method 1.650 times

- Method bilinear case I 2.713 times
- Bilinear case method II 1.366 times
- According to Euro code 2 1.832 times

For the third case, where the cross-sectional been added reinforcement by 60%, compared to the first case reinforcing this growth, compared t_0 reductions with reductions for time $t=\infty$.

- Numerical integration method 1.750 times
- Method bilinear case I 2.652 times
- Bilinear case method II 1.450 times
- According to the Eurocode-2 1.728 times

For the fourth case (Reinforcing symmetric reinforcement), where the cross-sectional been added reinforcement by 60%, compared t_o the first case reinforcing this growth, compared t_0 reductions with reductions for time $t=\infty$.

- Numerical integration method 1.553 times
- Method bilinear case I of 2.549 times
- Bilinear case method II 1.290 times
- According to the Eurocode-2 1.670 times

By increasing the amount of reinforcement on cross section element, the comparison of the results shows that deflection are coming decreasing: For the first case, where the cross-sectional been added reinforcement by 20%, compared to the first case reinforcement reduction in the percentage reductions for the times: $t = t_0$ highs for the time $t=\infty$.

	$v(t) = v(t_0)$ (%)	$v(t) = v(t=\infty)$ (%)
• Numerical integration method	26.00	20.54
• Method bilinear case I	0.65	1.50
• Bilinear case Method II	27.57	22:51
• According to the Eurocode-2	64.56	69.18

For the second case, where the cross-sectional been added reinforcement by 60%, compared to the first case reinforcing this reduction reinforcement, with the percentage of times: $t = t_0$ compared with decreases for time $t=\infty$.

	$v(t) = v(t_0)$ (%)	$v(t) = v(t=\infty)$ (%)
• Numerical integration method	73.56	56.61
• Method bilinear case I	2.68	5.96

• Bilinear case Method II	80.13	62.8
• According to the Eurocode-2	214.4	242.5

For the third case (Reinforcing symmetric), where the cross-sectional been added reinforcement by 60%, compared to the first case reinforcing this reduction with the percentage reductions for the times: $t = t_0$ highs for the time $t=\infty$.

	$v(t) = v(t_0)$ (%)	$v(t) = v(t=\infty)$ (%)
• Numerical integration method	26.46	28.55
• Method bilinear case I	4.30	11.94
• Bilinear case Method II	25.62	27.72
• According to the Eurocode-2	94.82	119.57

By comparing the results for the first addition of 20% reinforcement decreases according RBBA'87, two first methods, reduced (26; 27.57)% of the time t_0, and (20.54; 22.52)% of the time, while the Eurocode-2, we have a decrease of 64.56% reductions, the time t_0, and 69.18%, for the time $t=\infty$.

From the calculation of deflection according rules RBBA'87, shows that we reduce to 1.3 times the time t_0, respectfully 1.027 times, for time $t=\infty$ (numerical integration), and 1.37 times and 1.125 times, respectively bilinear method (II),and 3.22 times and 3.45 times as Eurocod-2.

From these results then conclude that: the two methods by RBBA'87, deflections decreased approximately to the extent that it increased reinforcing while under Euro cod reductions made 2-3 times more compared to the increase of cross section reinforcement.

Reinforcing case symmetrical cross-sectional deflections are larger compared with the same amount of reinforcement for cross section, but the amount of reinforcement is the largest in the drawing, this conclusion is that in addition to the amount of reinforcement in reduction of element has a role reinforcement position in the cross section.

During the reduction process, influence the phenomenon of "creep", since the delay time is increased from the initial time until infinity, which causes increased growth reductions over time. Besides delay in reducing the impact of reinforced concrete elements has also process shrinkage.

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